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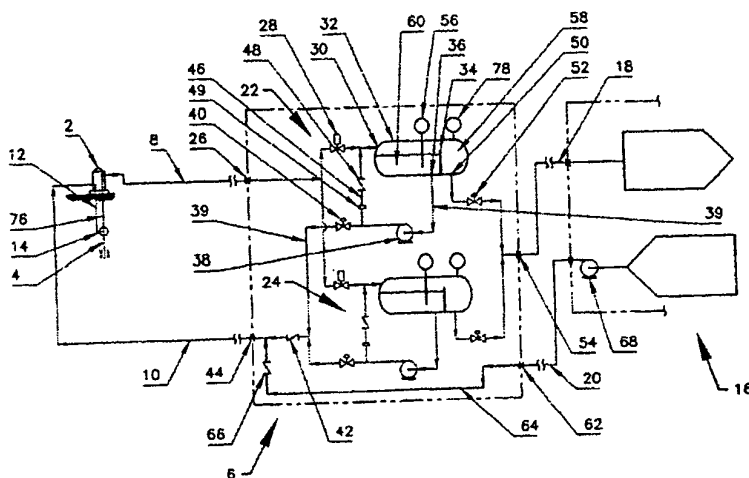
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[Continued on next page]

(54) Title: **BOREHOLE PRODUCTION BOOSTING SYSTEM**



(57) Abstract: Method and apparatus for assisting the flow of production fluid from a hydrocarbon wellbore (4) to a remote host facility (16) including a separation facility (6) situated close to the wellbore (4). Jetting fluid is supplied initially from the host facility (16) to a downhole jet pump (14) via the separation facility (6) for assisting the flow of production fluid from the wellbore (4) to the separation facility (6) where the resulting mixture enters one of two parallel gravity separation chambers (32). Separated jetting fluid (60) is recirculated to the jet pump (14) via a pump (38) and production fluid is routed to the host facility via a production pipeline (18). A jetting fluid supply pipe (20) can be of relatively small diameter and the production pipeline (18) does not have to be enlarged to accommodate jetting fluid returned to the host facility (16).

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BOREHOLE PRODUCTION BOOSTING SYSTEM

The present invention relates to a method and system for boosting the supply of production fluid from a hydrocarbon wellbore or borehole.

When a reservoir of production fluid, such as oil, has a low natural pressure and/or the fluid has a relatively high density, there is a need to boost the pressure of the fluid at or near the reservoir surface in order to achieve satisfactory production rates over the life of the reservoir.

One technique is to install a mechanical pump at a "downhole" location. Such pumps are typically electrically driven by a supply of high voltage electricity provided from an associated host facility which may be tens of kilometres away. The provision of a high voltage power supply for the pump motors is expensive. Furthermore, the pump is installed in a hostile environment which is hot and corrosive and relatively inaccessible. Pump maintenance, which is almost inevitably required, necessitates shutting the well in, thus interrupting production and possibly leading to restarting problems.

Another newer but existing technique is to install a hydraulically driven mechanical pump at a downhole location. Such pumps are typically driven by a supply of pressurised water, the supply of which is costly. Accessibility and maintenance problems apply as discussed above.

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A different technique is to use a jet pump which is installed at a downhole location. Such a pump is supplied with pressurised jetting water from the host facility which is mixed with the production fluid by the jet pump. The resulting mixture is then conveyed back to the host facility. Additional costs arise from:

- (a) the provision of a relatively large diameter high pressure pipe to supply the required quantity of pressurised jetting water to the wellbore;
- (b) the requirement for a production pipe which is large enough to accommodate the jetting water in addition to the production fluid; and
- (c) separation of the jetting fluid from the production fluid at the host facility.

An object of the invention is to provide a method and system which overcome at least some of the above-mentioned disadvantages of the prior art.

Thus, according to the invention there is provided a method of boosting production from a wellbore having a downhole jet pump and a remote host facility, the method comprising the steps of:

- (a) providing a separation facility substantially closer to the wellbore than the host facility;
- (b) providing means to deliver jetting fluid under pressure to the jet pump;
- (c) entraining wellbore production fluid with a flow of the jetting fluid in the jet pump and conveying the resulting mixture to the separation facility;
- (d) separating a majority of the jetting fluid from the mixture; and
- (e) recirculating the separated jetting fluid back to the

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jet pump and entraining further production fluid therewith.

A single separation facility may provide jetting fluid to a plurality of and possibly all wellbores in a field.

Such a method may only require a relatively small diameter conduit for supplying a batch of jetting fluid to the separation facility. Once adequate jetting fluid has been provided, this conduit will no longer be required for this purpose. The pipe for conveying production fluid from the separation facility to the host facility need not be enlarged to cater for conveying the jetting fluid. Separation at the host facility can be avoided as can the provision, from the host, of a continuous flow of appropriately treated jetting fluid. The problems associated with a downhole mechanical pump discussed above are also avoided.

Preferably at least 90% and more preferably substantially all of the jetting fluid is separated from the mixture by the separation facility in order to minimise the volume of fluid for conveyance to the host facility and in order to minimise or preferably eliminate the requirement for additional jetting fluid from the host facility.

To maximise the savings resulting from the invention, the separation facility is preferably situated at or close to the wellbores.

Preferably the separation facility includes a pump

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which is used to pressurise the separated jetting fluid for assisting its recirculation.

Separation is preferably effected by gravity separation which relies on the jetting fluid and the production fluid having different specific gravities. Gravity separators are robust and suitable for use in a hostile location which may be difficult to access.

According to a second aspect of the invention there is provided a system for boosting production from a wellbore situated remotely from a host facility comprising a downhole jet pump, pressurising means for supplying the jet pump with pressurised jetting fluid for forming a mixture of jetting fluid and wellbore production fluid, separation means situated substantially closer to the wellbore than the host facility including separator means for separating a majority of the jetting fluid from the mixture and recirculation means for delivering the separated jetting fluid back to the jet pump for entraining further production fluid.

Preferably the separator means includes at least one gravity separation chamber.

In order to provide system redundancy to minimise the chance of wellbore shut-in being required, preferably the separator means includes at least two separators for separating the mixture which are connected in parallel with each other.

If the separator means includes throttling means arranged to control flows of production fluid and jetting

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fluid out of the separation chamber, control of the separation means can be easily effected, possibly from a control module situated at the separation means.

The invention will now be described by way of example only with reference to the accompanying schematic figures in which:

FIG. 1 shows a system suitable for putting the invention into practice;

FIG. 2 shows the components of the system of Fig. 1 in greater detail; and

FIG. 3 shows a typical jet pump which will be situated at a downhole location in the systems shown in Figs. 1 and 2.

In the following description the terms production fluid and jetting fluid will be employed. These will generally be oil and water (appropriately treated) respectively but could comprise other fluids or mixtures of fluids.

A system for putting the invention into practice is shown in Fig. 1. The system includes at least one wellhead tree 2 which routes fluids from a wellbore or lower production tubing 4 to a separation facility 6 via a mixture pipe 8. A jetting fluid delivery pipe 10 extends from the separation facility 6 to the wellhead tree 2 for supplying jetting fluid to a downhole jetting fluid conduit 12 and hence to a downhole jet pump 14. The separation facility 6 is connected to a host facility 16 by a production pipeline 18 and a jetting fluid supply pipe 20.

The components of the system will be described in detail with reference to Fig. 2.

The separation facility 6 includes first and second duplicated separating means 22 and 24 only the first 22 of which will be described in detail. Only one separating means may be provided.

The mixture pipe 8 from the wellhead tree is connected to a mixture inlet 26 which is connected via a failsafe valve 28 to an inlet 30 of a separator chamber 32 containing a weir 34. A first outlet 36 of the chamber 32 is connected by a jetting fluid conduit 39 containing a recirculation pump 38, a throttle valve 40 and a non-return valve 42 to a jetting fluid outlet 44 of the separation facility 6. A recirculation loop pipe 46, containing a non-return valve 48 and a pressure restricting device 49, connects the jetting fluid conduit 39, downstream of the recirculation pump 38, to the inlet 30 of the chamber 32.

A second outlet 50 of the chamber 32, situated on the opposite side of the weir 34 to the first outlet 36, is connected via a throttle valve 52 to a production fluid outlet 54 which is connected to the production pipeline 18 leading to processing equipment on the host facility 16.

The chamber 32 includes a level sensor 56 for determining the level of the interface between the production fluid 58 and jetting fluid 60 within the chamber 32.

The jetting fluid supply pipe 20 from the processing

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equipment on the host facility is connected to a jetting fluid inlet 62 of the separation facility which is connected via a jetting fluid conduit 64, containing a non-return valve 66, to the jetting fluid outlet 44.

The host facility 16 includes apparatus (not shown) for processing production fluid 58 received through the production pipeline 18 and a pump 68 for pumping jetting fluid (water treated as required to inhibit corrosion and hydrate formation problems etc. upon mixing with the production fluid) to the separation facility 6.

The jet pump 14 shown in Fig. 3 is a conventional jet pump and will accordingly only be described in outline. The jet pump includes a nozzle 69 into which jetting fluid is fed (arrow A) from the jetting fluid conduit 12. Production fluid is routed to the jet pump via a lower production tubing conduit 70 (arrow B) from the lower production tubing 4, which opens into a low pressure entrainment region 72 at an outlet end of the nozzle 68. An intake nozzle 74, also opening into the low pressure entrainment region 72, is connected to upper production tubing 76 for delivering a mixture of production and jetting fluid (arrow C) to the wellhead tree 2 via the wellbore riser 76.

The operation of the system will now be described.

When production from the lower production tubing 4 needs boosting, for example because the well pressure is too low, a batch of jetting fluid will be pumped by the host pump 68 down the jetting fluid supply pipe 20 to the jetting fluid inlet 62 of the separation facility 6 where

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it passes through the conduit 64 to the jetting fluid outlet 44 and on through the jetting fluid delivery pipe 10 to the downhole jetting fluid conduit 12.

The jetting fluid then enters the jet pump 14 (arrow A) and is forced through the nozzle 69 into the entrainment region 72 where a lower pressure zone occurs causing production fluid to be drawn into the jet pump through the lower production tubing conduit 70 (arrow B) where it mixes in the entrainment region 72 with the jetting fluid. The resulting mixture then passes into the intake nozzle 74 and leaves the jet pump 14 up the upper production tubing 76 (arrow C).

On emerging from the wellhead tree 2, the mixture passes through the mixture pipe 8 and is conveyed to the inlet 30 of the chamber 32 via the mixture inlet 26 and the failsafe valve 28. Upon entering the chamber 32, as a consequence of their different specific gravities, the denser jetting fluid 60 (water) occupies the region to the left of the weir 34 (as shown in Fig. 2) and the less dense production fluid (oil) passes over the weir 34 into the region to the right thereof. Once the level sensor 56 detects that the interface between the jetting fluid 60 and the production fluid 58 has reached the level shown in Fig. 2 (i.e. partway up the weir) the supply of jetting fluid from the host facility will be halted. Thereafter, jetting fluid 60 is drawn from the chamber 32 by the recirculating pump 38 and routed to the jetting fluid outlet 44 via the jetting fluid conduit 39 from where it travels on to the jet pump and recombines with further production fluid as described above. Meanwhile, production fluid leaves the chamber 32 via the second

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outlet 50 (as a consequence of chamber pressure) and passes via the throttle valve 52 to the production fluid outlet 54 and through the production pipeline 18 to the host facility for processing.

A control system (not shown) receives signals from the level sensor 56 and a pressure sensor 78 and controls the throttle valves 40 and 52 and the recirculation pump 38 to maintain the interface between the fluids in the chamber 32 at the required level and the overall pressure in the chamber 32 at an appropriate level. For example, if the amount of jetting fluid in the chamber 32 needs to be increased, the throttle valve 40 will be closed slightly in order that jetting fluid will be forced through the recirculation loop pipe 46 back into the chamber 32.

Accordingly, the same batch of jetting fluid will be cycled repeatedly between the jet pump 14 and the separation facility 6. Hence, in the case of local seawater being deemed unacceptable for the purpose only a relatively small bore pipe 20 will be required for delivering the initial batch of jetting fluid to the separation facility 6 and the production pipeline 18 does not need to be unnecessarily enlarged so as to accommodate a flow of jetting fluid in addition to production fluid. Furthermore, any tariff charged by the host facility owner will only be in respect of production fluid delivered thereto and will not be increased as a consequence of delivering jetting fluid thereto.

While the invention has been described in the context of a subsea hydrocarbon field, it would also be applicable

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to other areas where access posed a problem, for example
in swampy areas or remote locations.

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CLAIMS:

1. A method of boosting production from a wellbore (4) having a downhole jet pump (14) and a remote host facility (16), the method comprising the steps of:
 - (a) providing a separation facility (6) substantially closer to the wellbore (4) than the host facility (16);
 - (b) providing means (38, 68, ...) to deliver jetting fluid (60) under pressure to the jet pump (14);
 - (c) entraining wellbore production fluid with the flow of the jetting fluid in the jet pump (14) and conveying the resulting mixture to the separation facility (6);
 - (d) separating a majority of the jetting fluid (60) from the mixture by means of the separation facility (6); and
 - (e) recirculating the separated jetting fluid (60) back to the jet pump (14) and entraining further production fluid therewith.
2. The method according to claim 1 wherein at least 90% of the jetting fluid (60) is separated from the mixture by the separation facility (6).
3. The method according to claim 2 wherein substantially all of the jetting fluid (60) is separated from the mixture by the separation facility (6).
4. The method according to any preceding claim wherein the separation facility (6) is situated at or close to the wellbore (4).
5. The method according to any preceding claim wherein

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the separation facility (6) includes a pump (38) which is used to pressurise separated jetting fluid (60) for assisting its recirculation.

6. The method according to any preceding claim wherein the separation is effected by gravity separation.

7. A system for boosting production from a wellbore (4) situated remotely from a host facility (16) comprising a downhole jet pump (14), pressurising means (38, 68) for supplying the jet pump (14) with pressurised jetting fluid (60) for forming a mixture of jetting fluid (60) and wellbore production fluid, a separation facility (6) situated substantially closer to the wellbore (4) than the host facility (16) including separation means (22, 24) for separating a majority of the jetting fluid (60) from the mixture and recirculation means (10, 12, 38, 39) for delivering the separated jetting fluid (60) back to the jet pump (14) for entraining further production fluid therewith.

8. The system according to claim 7 wherein the separation means (22, 24) includes at least one gravity separation chamber (32).

9. The system according to claim 7 or 8 wherein the separation means (22, 24) includes at least two separators (32) for separating the mixture which are connected in parallel with each other.

10. The system according to claim 7, 8 or 9 wherein the separation means (22, 24) includes throttling means (40, 52) arranged to control flows of production fluid and

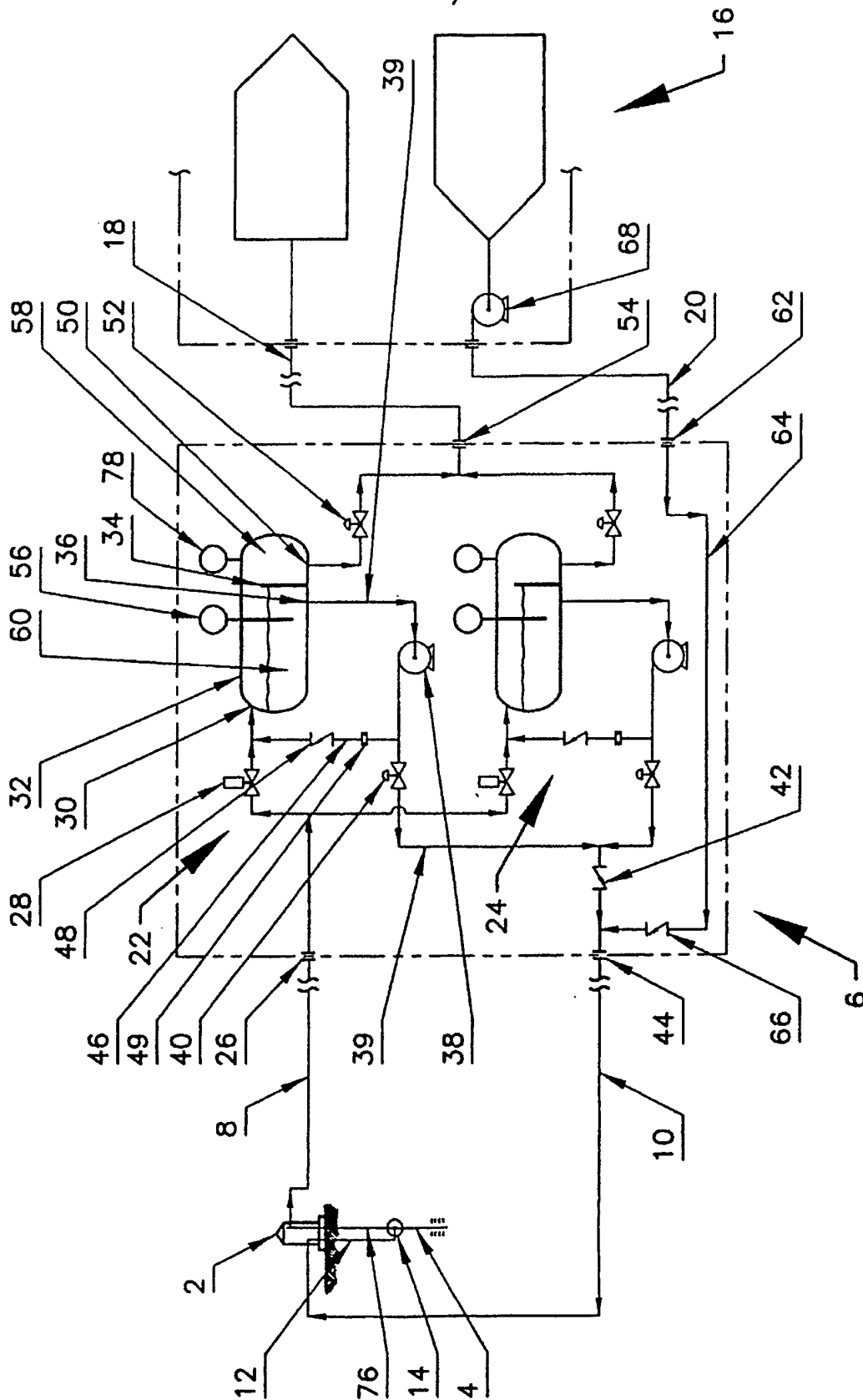
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jetting fluid (60) from the separation means (22, 24).



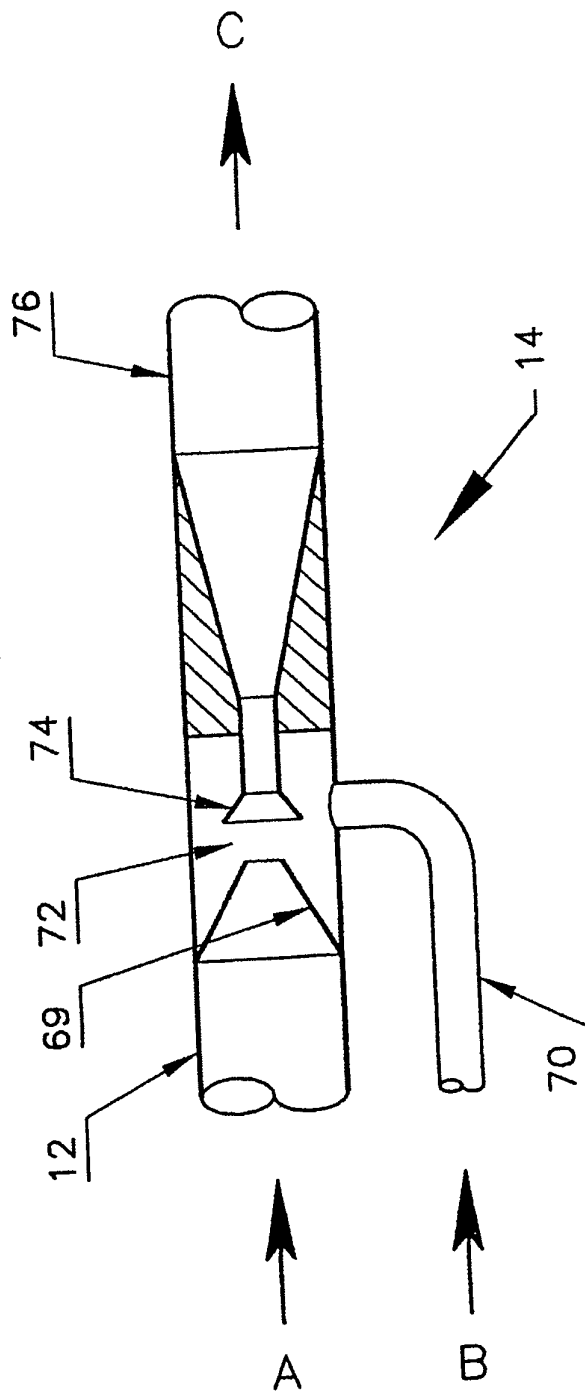
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FIG 2



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FIG 3



INTERNATIONAL SEARCH REPORT

International Application No

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A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 E21B43/36 E21B43/12 E21B43/34

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 E21B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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X	US 3 951 457 A (REDFORD DAVID ARTHUR) 20 April 1976 (1976-04-20) column 3, line 29 - line 39	1,4,7,9
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Further documents are listed in the continuation of box C.



Patent family members are listed in annex.

* Special categories of cited documents:

- *A* document defining the general state of the art which is not considered to be of particular relevance
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- *X* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- *Y* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
- *&* document member of the same patent family

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INTERNATIONAL SEARCH REPORT

International Application No

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT		
Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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INTERNATIONAL SEARCH REPORT

Information on patent family members

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